

3. DESIGN PARAMETERS

3.1 Introduction

This section presents site-specific information and conditions that affect the design of the Groundwater Remedy components, and how they are considered during design. Long-term operability and sustainability will also be considered during design. Table 3-1 summarizes key design considerations for each of the Groundwater Remedy components.

The Groundwater Remedy consists of a combination of existing technologies and an innovative treatment system. The Groundwater Remedy consists of two major components:

1. Funnel-and-Gate Treatment – installed downgradient of the Closed CKD Pile, the system intercepts the groundwater that is affected by the Closed CKD Pile. The intercepted groundwater is treated in a subsurface engineered treatment zone for release to Sullivan Creek through a subsurface engineered outfall that will be subject to an NPDES permit.
2. Gravity Drain – installed along the southeastern edge of the Closed CKD Pile, the gravity drain captures groundwater that might otherwise contact the Closed CKD Pile.

The funnel-and-gate concept uses a slurry wall, or similar barrier wall technology, to passively intercept the groundwater and direct the water toward a central treatment corridor. The upgradient side of the barrier wall funnel would be supplemented with a gravel French drain. The gravel would help to convey water along the barrier wall funnel to the treatment corridor, and it would lower the groundwater table in the vicinity of the funnel. The treatment corridor will use the technology evaluated during bench and pilot-scale testing to treat groundwater by diffusing carbon dioxide into the CKD-affected groundwater [GeoSyntec, 2003]. Carbonic acid is formed when carbon dioxide is diffused into the groundwater. The carbonic acid lowers

the pH, which causes the dissolved indicator substances (i.e., metals) to precipitate. The treated groundwater will then migrate to Sullivan Creek.

The gravity drain is a source control technology designed to supplement the funnel-and-gate components. Horizontal directional drilling techniques will be used to install a drain pipe under the southernmost CKD, connecting the barrier wall funnel and the upland area above and upgradient of the Closed CKD Pile. The gravity drain will be installed on the southern side of the Closed CKD Pile. Depending on water quality, the intercepted water will be routed to the barrier wall funnel for treatment or routed to the downgradient side of the barrier wall funnel.

3.2 Design Considerations

3.2.1 Summary of Geology, Hydrogeology and Groundwater Conditions

A general geologic and hydrogeologic description of the Site is summarized above in Sections 2.3.2 and 2.3.3. Key design considerations are summarized in Table 3-1. Details central to the design of the Groundwater Remedy include vertical and horizontal hydraulic conductivity, groundwater table elevation, and lithology. These data are included in Appendix A and Figures 3-2 and 3-3, and are summarized below:

- Holocene alluvium (sands and gravels) – horizontal hydraulic conductivity, average 1×10^{-3} ft / min;
- Glacial sediments (silt and clay) – vertical hydraulic conductivity, average 1×10^{-6} ft / min; and
- Groundwater table generally within three feet of existing ground surface within floodplain area.

The lithology is highly variable within the floodplain. Boulders present within the alluvial deposits will affect layout and construction schedules. The finer materials within the excavated alluvial sediments may be considered for re-use within

the project (e.g., fines within soil-bentonite backfill, sands and gravels for Site grading, and larger aggregate size for natural creek bank stabilization).

3.2.2 Creek Bank Geomorphology

A critical component of design involves the connection of the treatment system corridor to Sullivan Creek. This connection will be constructed and reinforced using biostructural elements appropriate to the Sullivan Creek geomorphology and to maintain the natural aesthetic of the area.

As described in previous documents submitted to Ecology, upstream of the Site Sullivan Creek is confined within a canyon where the stream channel is deeply incised in the bedrock substrate [EIP, 1999]. Downgradient of the former Sullivan Creek Hydroelectric Plant, Sullivan Creek passes under State Route 31 in the immediate vicinity of the Site. It is approximately there that the creek exits the canyon into an alluvial floodplain. This floodplain constitutes the terminal 0.4-mi section of Sullivan Creek prior to its confluence with the Pend Oreille River.

A few miles upstream of the Site, both Sullivan Lake and Mill Pond trap gravel and finer sediments from the contributing flows to Sullivan Creek [EIP, 1999]. Due to the high water velocities through and out of the canyon, the lower reaches of Sullivan Creek contain primarily erosional products from the bedrock substrate, generally large, rounded cobbles and boulders. Historically, the highly-braided stream channel has then meandered through the floodplain in the immediate vicinity of the Site. The current creek flow path leads a braided channel of Sullivan Creek to the base of an eroding bluff, less than 20 ft downgradient of Lehigh property along Sullivan Creek. The creek bank at the toe of the eroding bluff has been temporarily stabilized by an engineered "chaotic crib" consisting of irregularly-placed tree trunks and logs.

The Sullivan Creek bank along the Site consists of geologic deposits of varying aggregate sizes, dominated by large cobbles and boulders immediately along the water's edge. Historical overland flow from upland areas above the Closed CKD Pile has carried erosional sediments to Sullivan Creek. As these overland flows reached the floodplain, finer sediments and vegetative debris were deposited over the larger

aggregate sizes contributed by Sullivan Creek. As a result, a veneer of finer sediments currently exists overtop of the creek deposits with scattered vegetation rooted in this matrix along portions of the water's edge adjacent to the Site.

3.2.3 Quantities and Site Constraints

Key design considerations for Groundwater Remedy installation and operation include: Site lithology and groundwater flow within the upper groundwater aquifer, and surface water hydrology (both upgradient and downgradient of the system). Key design considerations for long-term system efficacy include: efficiency of the gravity drain, efficiency of the treatment system, system remoteness, and climatological influences (e.g., flooding).

Construction will occur mostly in the surficial Holocene alluvium soils at the Site where the CKD-affected groundwater flows. The quantity of geologic materials to be excavated during construction of the funnel-and-gate portions of the Groundwater Remedy is anticipated to be approximately 7,000 to 8,000 cubic yards (CY). An additional approximately 2,000 CY will be excavated from the treatment corridor. Although portions of this material may be re-used (e.g., as part of the soil-bentonite backfill, or natural cobbles along the creek bank), some of the material will be disposed off-site. During the excavation of these components and installation of integral systems, dewatering will be necessary. The volume and chemical characteristics of the water extracted during construction dewatering, as well as the duration of the construction dewatering, will depend on conditions encountered in the field. Water generated during construction dewatering will be treated by: (1) injecting it into the pilot system during construction; (2) storing it above-ground for treatment with CO₂ or later injection to the treatment system; or (3) direct discharge to Sullivan Creek without treatment, based on the water quality testing requirements that are to be specified in the NPDES permit.

One portion of the excavation, the treatment corridor, is excavated adjacent to the Sullivan Creek bank. This excavation work will be performed during a time specified in the substantive requirements of Hydraulic Project Approval (HPA) from the Washington Department of Fish and Wildlife (Fish and Wildlife), known as the Fish and Wildlife-approved Work Window, which is typically between 1 July and 31 August

for this portion of Sullivan Creek. However, Fish and Wildlife may extend the Work Window due to the historically low creek levels in September. The schedule and cost of the construction described in this document are based on the understanding that the remainder of the construction will not be subject to the Fish and Wildlife Work Window. Also note that this project is to be installed within the Sullivan Creek floodplain. The flows within Sullivan Creek are largely regulated by controlled discharges from Sullivan Lake and Mill Pond. Although certain elements of the Groundwater Remedy will incorporate flood-resistant components (e.g., tie-downs), the project will not include provisions to impede flooding of the Site.

A large construction area will be required to prepare, excavate and handle the excavated material. The construction and staging operations will be handled within Lehigh property boundaries. Because Washington State Department of Transportation (WSDOT) plans to re-align State Route 31 in the vicinity of the Site, Lehigh will be coordinating needed work space with WSDOT.

Also of note are the seasonal climate variations. Temperatures vary significantly, with monthly average temperature extremes ranging from below 10°F to above 90°F [GeoSyntec, 2001]. The Site mean annual precipitation is 28 in. [GeoSyntec, 2001]. The working area is typically covered by snow from November or December through March.

The Groundwater Remedy is anticipated to be operating for several decades. Based on the anticipated design life and the remoteness of the area, specific design considerations will be incorporated to facilitate operation and maintenance of the Groundwater Remedy. These include automated systems such as telemetric operation to allow the system's status to be monitored from remote locations.

3.3 Groundwater Remedy Elements

3.3.1 General Description

The Groundwater Remedy consists of several elements. Each of the elements is described in the following sections, including:

- Site Preparation;
- Building Expansion;
- Carbon Dioxide Tanks;
- Diaphragm Walls;
- Carbon Dioxide Treatment System;
- Treatment Corridor;
- French Drains;
- Groundwater Barrier Walls;
- Streambed Erosion Control – Treated Water Discharge Location;
- Gravity Drain;
- Wetlands Mitigation Measures;
- Site Restoration; and
- Institutional Controls.

This section also describes Site preparation and restoration activities. Preliminary design calculations are provided in Appendices B and C for anticipated flow within the treatment corridor and carbon dioxide dosage, respectively. Design details provided in the following sections and the appendices are for general reference and scaling, and may be modified during the design of the Groundwater Remedy. Where appropriate, standard engineering specifications will be followed during the design and installation of system components (e.g., WSDOT and / or American Society of Testing and Materials (ASTM) or equivalent).

3.3.2 Site Preparation

Site preparation activities will be performed in accordance with a Site Management Plan to be prepared by Lehigh's contracting team. The Site Management Plan will include a description of storm water and surface water controls, outlining of equipment staging areas, Site clearing and preliminary grading, security and Site access, institutional controls during construction, and general health and safety precautions.

Site preparation is divided into two phases: Phase I, encompassing work in 2006, and Phase II, encompassing work scheduled for 2007 (see Section 7 and Table 7-1 for a more detailed description of the work schedule). Site preparation measures include controlled vegetation removal (i.e., protecting in-place as much of the woody vegetation as practicable, maintaining natural vegetative “screening,” removing only the vegetation that will impact construction operations). An area of degraded wetland (designated Category IV by the USCOE) will be impacted by Site construction activities. Lehigh will mitigate these impacts following construction of the Groundwater Remedy. Site preparation measures will also include rough grading to prepare the area for each of the system components, as well as protect it from surface water drainage during the construction phase. Appropriate Best Management Practices (BMPs) for limiting uncontrolled discharges from the Site will be employed by Site contractors. Phase I Site preparation measures include preparing the area where the building expansion foundation will be constructed as well as rough grading activities and contouring the site to allow for more efficient stormwater drainage. Phase II Site preparation measures include additional grading and vegetation removal to prepare for installation of the subsurface components of the Groundwater Remedy. Site activities will disturb more than one acre of ground, thereby requiring an NPDES permit for construction stormwater. The NPDES permit is expected to be issued by Ecology prior to commencement of site activities. The NPDES permit will include provisions for addressing water discharges during the construction process. Lehigh has also applied for an erosivity waiver from Ecology to allow a work to occur in 2006 in advance of the NPDES permit.

Excavation dewatering will likely be needed to construct the treatment zone and other associated subsurface engineered components. The water collected during dewatering will likely be discharged to Sullivan Creek for a limited period of time during construction. The treatment system will also not be operational for a period of time after it is constructed and prior to start-up. During this time water will migrate through the treatment zone and into Sullivan Creek without being treated with carbon dioxide. The NPDES permit is expected to allow for untreated discharges under these scenarios since they are integral to construction of the Groundwater Remedy.

3.3.3 Building Expansion

The existing Site improvements include a structure with dedicated electrical and plumbing. The existing structure is made of cinder-block and fiberglass corrugated panel walls and metal roofing. Portions of the structure are occupied by a machine shop. The existing building houses the control components for the pilot scale treatment system [GeoSyntec, 2003]

To create space for dedicated storage for the components of the full scale treatment system, the building will be expanded. The expansion will house the new components to be added for the full scale treatment system. Prior to beginning construction of the expansion, utilities such as water and electrical services will be evaluated and updated, as needed. The building expansion will likely be a one-story addition, having a plan area of approximately 1,200 square feet (30 ft by 40 ft). The building expansion will be in keeping with the existing structure aesthetic. The building will include a poured reinforced concrete foundation designed to support a carbon dioxide tank including tank mountings, and a structure having wide doors so the tank may be installed following completion of the building, or removed in case of malfunction.

An automated Supervisory Control and Data Acquisition (SCADA) system will be housed in the new building expansion along with other equipment necessary to distribute carbon dioxide to the full scale system and monitor the system remotely. The building expansion will be equipped with carbon dioxide sensors and alarms; these alarms will sound if levels in the air within the structure are above pre-determined action levels. The building will be secured and placarded to notify passersby of the building contents.

3.3.4 Carbon Dioxide Tanks

The existing structure houses a 14-ton tank containing carbon dioxide. In order to accommodate the design demand for a greater amount of carbon dioxide to be used in the full-scale system, the on site storage capacity will be increased (allowing the treatment system to function for longer periods of time before a carbon dioxide recharge

is necessary). The existing system will be augmented with a second 14-ton unit: a pre-manufactured skid-mounted, steel, carbon dioxide storage and distribution tank will be installed. The tank will be ASME certified, with Underwriters Laboratories (UL) listed components. The total carbon dioxide capacity will be 56,000 lbs.

The tanks will have the following features: automated refrigeration capabilities, pressure relief controls, and system automation for carbon dioxide distribution to the manifolds. The treatment skid will also include tie-downs for flood contingencies.

The pilot system will be abandoned after it is no longer needed and only the carbon dioxide tank and associated piping hardware will be re-used. The underground piping used for the pilot system will be de-commissioned and left in place.

3.3.5 Diaphragm Walls

The gate portion of the funnel-and-gate consists of a treatment corridor where carbon dioxide will be diffused into the groundwater. The treatment corridor will be excavated so that the treatment components may be installed. Diaphragm walls will be installed in-situ to provide structural integrity to the area to be excavated, as well as serve as the low permeability barrier walls for the gate through which groundwater is directed. The diaphragm walls will be constructed of reinforced concrete.

Construction of the diaphragm walls will be performed using slurry trench excavation techniques. First an elevated platform will be constructed to create a sufficient head differential between slurry and the surrounding groundwater table. Using extended track-mounted backhoes, the excavation will be advanced through the slurry and subsurface material. The diaphragm walls are approximately parallel to the groundwater flow direction through the gate. The walls will be constructed approximately 20-25 ft deep, and keyed into the underlying aquitard. The walls will be approximately 3 ft thick. The design dimensions will be based on the effective stresses (soil and water pressures) that will be present on the walls once the treatment corridor is excavated. Diaphragm wall reinforcement materials will be pre-assembled and lowered

into the excavation. Cement slurry will be tremied into the excavation around the reinforcement to complete the wall.

Groundwater flow and high pH conditions are important considerations for the long-term integrity of the diaphragm walls. The diaphragm walls will be constructed with materials that will be able to withstand the shear forces caused by the groundwater flowing through the treatment corridor and that will resist corrosion under the pH conditions that will occur in parts of the treatment corridor.

The diaphragm wall construction and design are influenced by the lithology encountered in the excavations in which the concrete walls will be built. The lithology will dictate the ease with which excavation and installation will occur. Lehigh will evaluate options such as installing the diaphragm walls deep into the confining layer of the aquitard or an anchor system (tie backs) to counteract the soil and water pressures that will be present. The diaphragm wall design will also consider the method of connection between the diaphragm walls and the groundwater barrier walls. This connection will likely be grouted in order to reduce groundwater seepage between the two subsurface walls.

Water will flow through the treatment corridor without being treated until the treatment system is connected and operational. See Appendix A for analytical data that describe the untreated water that will be discharged.

3.3.6 Carbon Dioxide Treatment System

The selection of the treatment process for the Groundwater Remedy was based on engineering calculations, chemical stoichiometry, and bench-scale and pilot treatment studies [GeoSyntec, 2000 through 2003]. A flexible carbon dioxide delivery system and a performance monitoring system within the treatment corridor will allow Lehigh to fine-tune operation, in particular, carbon dioxide delivery rates. Components of the Groundwater Remedy will be modified during installation and operation of the systems, based on site-specific constraints and field observations. After the two-year Optimization Phase specified in the CAP, the treatment system is expected to meet cleanup levels when operational. During the two-year Optimization Phase, cleanup

levels may not be met prior to discharge to Sullivan Creek even when the Groundwater Remedy is operational.

The carbon dioxide treatment system includes the mechanisms by which carbon dioxide is dissolved into Site groundwater. The two carbon dioxide storage tanks (Section 3.3.4) will contain the carbon dioxide that is diffused into the groundwater. The tanks store the carbon dioxide as a liquid and gas mixture, at approximately 300 pounds per square inch (psi). Shatter-resistant plastic pipe conduits such as high density polyethylene (HDPE) or acrylonitrile butadiene styrene (ABS) will connect the carbon dioxide tanks to the silicone tubing in the treatment corridor. These conduits will be equipped with moisture drop-outs to keep the lines clear. The carbon dioxide will pass through a series of pressure regulators that reduce the carbon dioxide from approximately 300 psi at the tanks to approximately 40 psi in the silicone tubing.

The treatment corridor lies at the mouth of the funnel and consists of in-situ carbon dioxide delivery system components (i.e., perforated pipes and silicone tubing) arranged and installed in the gravel corridor as shown in Figure 3-4. Mass transfer of carbon dioxide into the high pH water is achieved at the exterior walls of the gas-permeable silicon tubing. Treatment geochemistry is described in other documents previously submitted to Ecology as part of the FS process, and is summarized herein. Figure 3-5 shows a process flow diagram for the carbon dioxide diffusion process. Figure 3-4 shows the treatment corridor in plan and cross-sectional views. Figure 2-2 shows a process flow diagram for the overall treatment system. Carbon dioxide is distributed into the silicone tubing under approximately 40 psi of pressure. The pressure causes diffusion of carbon dioxide through the walls of the tubing into the groundwater.

The design will consider how to increase the efficiency of the treatment system. The efficiency of the carbon dioxide treatment system will be affected by a number of factors including: dosing, mixing, number of silicone tubes and the flow through the carbon dioxide treatment corridor. The silicon tube bundles will be placed in segments of pipes in U-shapes (see Figure 3-4). The high hydraulic conductivity gravel in the treatment corridor will encourage mixing. Several segments of carbon dioxide distribution pipes will be installed to give greater dosing control. System monitoring and maintenance wells will be placed within the treatment corridor to

monitor dosing. A “surface completion” will be added over the manifolds in the treatment corridor to protect the weather sensitive parts, and secure those areas.

3.3.7 Treatment Corridor Construction

The treatment corridor has been located in an area that:

- is relatively low topographically;
- contains a lower density of boulders and cobbles than the rest of the streambank; and
- is located as far as feasible from the bluff and the river bend to reduce the amount of energy that is imparted on the discharge location and surrounding streambank.

The mixing of carbon dioxide with CKD-affected groundwater occurs within the treatment corridor. The treatment corridor will be constructed by excavating the soil between the diaphragm walls and replacing it with fill material having high hydraulic conductivity relative to surrounding materials, and the carbon dioxide treatment system. The depth of the treatment corridor side walls is about the same depth as the barrier wall funnel (approximately 10 to 20 ft). The treatment corridor components are placed after approximately 2,000 CY of material from the treatment corridor are excavated. During construction, the treatment corridor will be dewatered to expose the full treatment corridor for the placement of treatment system components. The fill used in the treatment corridor will have a high hydraulic conductivity to allow flow throughout the corridor (i.e., reduce back-up in the system). The grain size of the fill will directly affect the groundwater flow through the treatment corridor. The fill will consist of non-reactive aggregate (likely granitic) to withstand the high pH that will be present in parts of the treatment corridor.

Prior to excavation in the treatment corridor, a system will be put in place to impede groundwater from flowing into the treatment corridor during excavations. One possible alternative is an engineered low permeability groundwater barrier temporarily

placed at both ends of the corridor. Another alternative is a groundwater dewatering collection trench placed near the ends of the treatment trench that diverts groundwater from the corridor and then is treated and surface discharged or pumped into surrounding drainage courses. These systems would be removed subsequent to completion of the corridor. These two systems and other alternatives will be evaluated as part of detailed design.

3.3.8 French Drains

The funnel portion of the funnel-and-gate consists of a groundwater barrier wall and high permeability wall (i.e., French drain). The French drains provide a relatively high permeability zone within the subsurface that will be used to conduct high pH groundwater to the treatment corridor. The French drains are upgradient and located several feet from the groundwater barrier walls (described in Section 3.3.9). The French drains will have a thickness of approximately two to three feet, depth of approximately 20 to 25 ft, and length of approximately 600 feet.

Prior to construction, the subsurface conditions along the proposed alignment will be evaluated, and, if needed, additional borings along the alignment will be installed to evaluate subsurface conditions (specifically depth to the aquitard along the precise alignment, and distribution of large sediments that would make construction difficult). The French drains will be excavated in a similar fashion to the diaphragm walls. Biodegradable slurry will be used to excavate the trench for the French drain. As the trench is excavated, biodegradable slurry will be added to keep the excavation open. Once the excavation is complete the gravel fill material will be added to the excavation. Slurry will be displaced by non-reactive (likely granitic), high permeability aggregate. A degradable slurry breakdown solution may be added to the wall to increase the rate of degradation of the biodegradable slurry.

3.3.9 Groundwater Barrier Walls

The second element of the funnel portion of the funnel-and-gate is the groundwater barrier walls. The barrier wall is a relatively low permeability zone within

the subsurface that will be used to conduct high pH groundwater to the treatment corridor. The barrier walls are downgradient and within several feet of the French drains (described in Section 3.3.8). The barrier wall will have a thickness of approximately two to three feet, depth of approximately 20 to 25 ft, and length of approximately 600 feet.

The barrier walls will be excavated in a similar fashion to the diaphragm walls, likely using slurry wall techniques. The barrier walls are aligned across the CKD-affected groundwater plume to capture and direct it to the treatment corridor. The barrier walls key into the upper few feet of the low-permeability glacial sediments that underlie the Site. The slurry composition, likely bentonitic slurry, will be compatible with high pH conditions.

The barrier walls will most likely be constructed using a soil-bentonite or soil-cement-bentonite mix. Though a slurry groundwater barrier wall is most likely, other low permeable barrier methods, such as PVC sheet pile or HDPE wall are being considered. If a slurry wall is installed, soil from the treatment corridor excavations may be used as fill in the slurry mix. Soil would be stockpiled to allow water to drain from it before re-use. The soil will have to be sieved to remove large rocks. This process could require a considerable amount of space on the construction site, but would limit the quantity of soil importation.

3.3.10 Streambed Erosion Control - Treated Water Discharge Location

After passing through the treatment corridor, the treated groundwater will discharge passively to the bank of Sullivan Creek. Although this flow is passive (i.e., not pumped), an increase in groundwater flow velocity occurs in the treatment corridor. This is due to constriction of flow area by the funnel-and-gate. The discharge location will be designed to dissipate the increased groundwater flows, control streambank erosion, and resist energy imparted by Sullivan Creek flow.

Lehigh will follow the Washington Department of Fish and Wildlife approach for design of erosion control structures in the Integrated Streambank Protection Guidelines (ISPG). The design will feature structural and biotechnical

components that integrate the use of native material to create an ecologically and aesthetically-focused system that does not exacerbate erosion along Sullivan Creek. Design considerations include:

1. The treatment system structures need to be well protected and buried.
2. The amount of energy and associated erosion potential is relatively high where Sullivan Creek makes a sharp turn immediately down gradient from the outfall.
3. Bank erosion should be controlled to protect the outfall and to reduce new sources of turbidity in Sullivan Creek.
4. A highly porous medium (i.e., high hydraulic conductivity) is required along the bank to facilitate outflow of the treated water through the treatment system.

The ISPG provides guidelines for selecting and designing streambank protection structures, including “structural” and “biotechnical” techniques. Biotechnical techniques use natural materials like rock, wood, and live plants. Mixed structural and biotechnical solutions are strong initially and grow stronger with time as the vegetation roots become established. There are many combinations of vegetation and structures that are referred to as biotechnical solutions. Because the treatment systems need to be well-protected and buried, the streambank protection will likely include a heavily armored core. A biotechnical solution could then be used to conceal the heavily armored core and build the streambank. A potential biotechnical solution for this Site consists of reinforced soil placed in lifts along the bank overtop a rock toe to address scour. Vegetation would be placed between the soil lifts and planted at the surface. The strength of such a structure increases over time as the vegetation becomes established. Vegetation provides habitat along stream banks, shaded riverine aquatic cover, temperature control, and provides hiding places and food supplies for aquatic animals. The armored rock core and toe overlain by vegetated soil would also resemble the existing Sullivan Creek streambank in the area.

Figure 3-4 presents a concept that uses an armored core, a rock toe, and biotechnical solutions to rebuild the streambank after construction, and provide a conduit to discharge groundwater. The vegetation acts to sequester fine sands and silts during higher flows and build streambank. The vegetation root system grows down into the gravel and helps anchor the soil lifts, vegetation, and rock toe. The soil lifts may be amended to provide more suitable growing conditions for plants. Specific plant types will be selected consistent with ISPG guidelines and site-specific considerations. Plants such as willows become well-established in 3 to 5 years. Once grown, the plants will provide the added hydraulic roughness as recommended in the ISPG.

To limit the potential for increased suspended solids and turbidity in Sullivan Creek, a temporary barrier will be placed in the creek prior to construction of the discharge location. The temporary barrier, which will not impede the majority of Sullivan Creek flow, will be located between the construction area and the main channel of Sullivan Creek. Temporary barrier usage is consistent with USCOE provisions and WDFW guidelines for preventing sediment to be released into Sullivan Creek. The USCOE has provided a Nationwide Permit 38 to allow construction of the streambank protection structures and placement of the temporary barrier waterward of the Sullivan Creek ordinary high water mark.

3.3.11 Gravity Drain

The gravity drain is a perforated drain pipe installed in the alluvium between the CKD and the underlying clay aquitard, under the southernmost margins of the Closed CKD Pile using horizontal directional drilling techniques. The gravity drain intercepts groundwater moving northward toward the Closed CKD Pile and conveys it to the southern tip of the south barrier wall (Figure 2-1). Since the purpose of the gravity drain is to intercept water before it contacts the Closed CKD Pile, water from the gravity drain should meet cleanup levels without treatment for discharge into Sullivan Creek via an outfall diversion near the existing sedimentation basin. If testing of the water intercepted by the gravity drain indicates that treatment is necessary, the water will join the water captured by the barrier wall funnel for eventual treatment and discharge to Sullivan Creek.

Directional drilling techniques will be used to install the gravity drain underneath State Route 31, beneath the Closed CKD Pile, and into the hillside. These directional drilling techniques allow the gravity drain to be installed following a near-horizontal path under the toe of the Closed CKD Pile, followed by an increasingly vertical path as the gravity drain extends farther under the Closed CKD Pile through the hillside. The final gravity drain design will include pipe diameter, boring diameter, location, pipe curvature, length and frequency of perforation, and expected flow from drain. The final design will also include the manner in which the gravity drain will be developed (e.g., surging, pumping, etc.) A critical design consideration is the geology that will be encountered while installing the drain using horizontal directional drilling. Large rocks or boulders or very soft soil will cause the gravity drain to change course. The course will be monitored and adjusted during construction to avoid installing the gravity drain within CKD.

A subsurface vault will be installed at the downgradient opening of the gravity drain. Inside the vault the gravity drain will be equipped with a valve that will be closed until the remainder of the Groundwater Remedy is constructed. Once the Groundwater Remedy is constructed the valve will be opened and used to direct the water toward the treatment corridor if needed, or for discharge without treatment if the water meets cleanup levels.

3.3.12 Wetlands Mitigation Measures

The existing Category IV wetlands will be damaged or filled during construction of the Groundwater Remedy components. The USCOE has issued a Nationwide Permit 38 to cover these activities. Efforts will be made to limit the damage to the wetlands, however some wetland damage is not avoidable.

The wetlands lost will be replaced 1:1, meaning for each acre impacted, an acre will be restored. A pre-survey of the wetland area exists and has been reviewed by the USCOE [USCOE, 2006]. The mitigation area will likely be along the natural drainage course that exists downgradient of the sedimentation pond, along the eastern boundary of the Site.

3.3.13 Site Restoration

Following construction of each of the Groundwater Remedy components, Site restoration activities will be performed to address the disturbances caused by construction. These activities will include:

- removing construction equipment and debris;
- grading the Site for storm water run-off; and
- re-vegetating areas of vegetation that were destroyed during construction.

3.3.14 Institutional Controls

After construction equipment has been removed and concurrent with final restoration activities, the construction phase will be completed with the implementation of several institutional controls at the project site. These will include:

- Fencing will be placed around the project area with proper signage in place.
- Restrictive covenants will be recorded to limit the uses of the property (including use of groundwater and disturbance of the Closed CKD Pile).